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EXPERIMENTAL INVESTIGATION OF EMISSION CHARECTERISTICS FOR METHYL ESTER MANGO SEED BIODIESEL OF DIESEL ENGINE

SRINIVAS[1] & ABHIMANYU R POSANGIRI[2]

[1]*Department of Mechanical Engineering, PDA College of Engineering, Kalburgi Karnataka, India*

[2]*Professor, Department of Automobile Engineering, PDA College of Engineering, Kalburgi, Karnataka India*

ABSTRACT

Biodiesel is one of the needful research areas in growing automobile usage era. Most of the researchers focused on the biodiesel as alternate fuel areas but the ignition levels are not reached as that of pure diesel. This work focusing on the extraction of the methyl ester mango seed oil form naturally available mango seeds and experimental investigation of the emission characteristics in a single cylinder, 4-stroke diesel engine for Methyl Ester Mango Seed (MEMS) biodiesel compared with the pure diesel. The MEMS biodiesel may be an alternative for the conventional diesel fuel. The experiments were conducted to estimate the emission characteristics for pure diesel, B10, B20 and B30 MEMS biodiesels, for 210 bar, 225 bar and 250 bar injection pressures at for different engine loads. The emission characteristics of the diesel engine are enhanced like HC (ppm), CO%, CO_2%, O_2% and NO_x (ppm) for the all the engine loads, at different injection pressures for pure diesel, B10, B20 and B30 MEMS biodiesels. The CO emission for B10 and B20 was inferior to the diesel at full load, whereas CO emissions wee higher at B30 biodiesel for all engine loads and the NO_x emissions of MEMS blends were superior than diesel fuel.

***KEYWORDS**: Biodiesel, MEMS Oil, Emissions & 4-Stroke Diesel Engine*

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Original Article

INTRODUCTION

The utilization of the petroleum products are increased due to enhancing the automotive vehicles in world which leads to the depletion of the petroleum products inturn increases the fuel cost. The combustion of diesel fuel in the automobiles produces enormous environmental pollution. The pollution caused by the exhaust gas of the diesel engine leads global warming and causes damage to the ozone layer [1-2]. The automotive engineering are looking for the alternative fuels to overcome the above problems. Many researchers are focusing on the investigation of the alternative fuels for diesel fuel and the performance and emission characteristics were also presented [4-7]. Few researchers were investigated the performance and emission charecteristics of the diesel engine for different biodiesels are discussed here. Hiregoudaru Yerrannagoudaru et al, [8] have investigated the performance and emission characteristics of the coconut oil based biodiesel fueled diesel engine by varying different parameters of the engine. The emissions were marginally reduced for biodiesel compared to pure diesel. Arinash Kumar Agarwa and Rajamanoharan K [9] have investigated the performance and emission characteristics of the karanja oil and its blends biodiesel fueled diesel engine by varying different parameters of the engine. The emissions were marginally reduced for biodiesel compared to pure diesel. The emission reduces as the

percentage of the blend increases in the pure diesel. P.K Devan and N.V. Mahalakshimi, [10] have investigated the performance and emission characteristics of the methyl ester of paradise oil biodiesel fueled diesel engine by varying different parameters of the engine. The emissions were marginally reduced for biodiesel compared to pure diesel. The emission reduces as the percentage of the blend increases in the pure diesel [11]. Shrirao P N and Pawar A N [12] have investigated the performance and emission characteristics of the thermal barrier coated with mullite diesel engine by varying different parameters of the engine. The performance was enhanced due to the thermal barrier coating and emissions were marginally reduced compared to un-coated diesel engine [13-18]. The present work aims in the preparation of the methyl ester mango seed biodiesel from non edible mango seed oil and emissions in the diesel engine were determined by varying the engine parameters like injection pressure and engine load for different MEMS biodiesels.

PREPARATION OF MEMS OIL

The previous studies were shown the importance of using of non edible oil as the as an alternative fuel for automotive applications because it is not good for human consumption. India is the major producer of mango which is used for making juice and pickles in the industries. These mango seed kernels have the 10-15% oil content. This mango seed are collected and the outer shell was removed to get the kernel. These kernels were dried at room temperature for 15days. The first stage of Mango Seed Oil (MSO) was derived during crushing of kernels. This mango seed oil is then filtered and used for preparation of methyl ester mango seed oil. The mango seed oil was heated to 650^{o}C with the addition of methanol and KOH. Then the mixture was stirred for 2 hours to obtain the methyl ester mango seed oil. Then the biodiesels were prepared by the MEMS oil by blending with the pure diesel. Three types of biodiesels were prepared by mixing the 10% of MEMS oil in pure diesel to prepare B10 biodiesel. Similar process was adopted for the extraction of biodiesel [19-22]. The B10, B20 and B30 biodiesels were prepared and are used in the experimentation to investigate the emission charecteristics. The properties of the biodiesel were determined and presented in the table 1.

Table 1: Properties of Pure Diesel and Biodiesels

Property	Pure Diesel	B10-Bi0 Diesel	B20-Bi0 Diesel	B30-Bi0 Diesel
Specific gravity	0.8298	0.8512	0.8646	0.8796
Kinematic viscosity	2.57	3.8	4.42	5.18
Flash point 0C	37	82	102	166
Fire Point 0C	40	92	113	179
Power point 0C		-3C	+3C	+5C
Gross calorific value in kJ/kg	44738	43230.78	42606.91	41924.01
Cetane number	50	52.2	51.8	51.6

METHODOLOGY OF EXPERIMENTS

The single cylinder 4-str0ke diesel engine test rig with emissions measuring instrument was shown in the figure 1a was used for the investigation of the emission characteristics of the biodiesel fuels. This engine is electrically loaded air cooled engine. This engine has the facility to vary the injection pressure, compression ratio, engine speed, engine load and air inlet temperature. The engine is interfaced to computer with software which tabulates the output results. The experiments were conducted for different blends B10, B20, B30 biodiesels by varying injection pressures 210 bar, 225 bar and 250 bar at 0.2, 3, 6, 9, 12 kg engine loads. The emissions characteristics were recorded in un-coated condition. The piston and piston head were coated by 50 micron thickness of zirconia thermal barrier coating ceramic material by plasma spray coating technique [23-26]. The experimentations were repeated after fixing the coated piston into the test rig.

The results were discussed in the next section.

Figure 1(a): Single Cylinder 4-Stroke Diesel Engine Test Rig with Emissions Measuring Instrument

Figure 1(b): Zirconia Coated Piston and Piston Head

Table 2: Experimental Data

Engine Details	Combustion Parameters	Performance Parameters
IC Engine with p0wer 3.50 kW @ 1200 rpm	Specific Gas C0nst (kJ/kgK): 1.00,	Fuel Type: Diesel
Cylinder B0re 87.50(mm)	Number of Cycles: 10,	Fuel Pipe dia (mm): 12.40
Str0ke Length 110.00(mm),	Adiabatic Index: 1.41	Ambient Temp. (Deg C): 27
C0nnecting R0d length 234.00(mm)	Polytr0phic Index: 1.13	Dynam0meter Arm Length (mm): 185
C0mpression Rati0 16.00,	Air Density (kg/m^3): 1.17	Pulses Per rev0lution: 360
Swept v0lume 661.45 (cc)	Cylinder Pressure Ref.: 4	Orifice C0efficient of Discharge: 0.60

RESULTS AND DISCUSSIONS OF EMISSIONS FOR COATED ENGINE

Influence of Engine Load and MEMS Biodiesels on HC Emissions for Coated Engine

Figure 2 illustrate the irregularities of HC emission with load for pure diesel and MEMS biodiesels at pressure of 210 bars. The HC emissions are minimal for B30 biodiesel at higher engine loads whereas has HC emissions are higher for B20 biodiesel when the engine operated at higher loads. This shows that HC emissions enhances as the MEMS concentration decreases in the pure diesel.

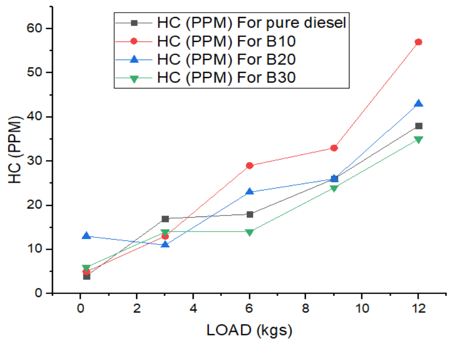

Figure 2: Influence of Engine Load and MEMS Biodiesel on HC Emissions At 210 Bar Injection Pressure

Figure 3 demonstrates the irregularities of HC emission with load for pure diesel and MEMS biodiesels at pressure of 225 bars. The HC emissions are minimal for B20 biodiesel at higher engine loads whereas has HC emissions are higher for B30 biodiesel when the engine operated at higher loads. This graph explains that the HC emissions released for biodiesel were nearer to the HC emissions released for pure diesel.

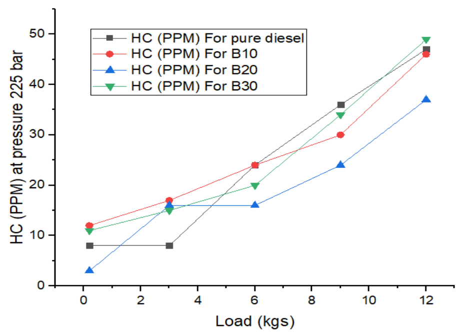

Figure 3: Influence of Engine Load and MEMS Biodiesel on HC Emissions At 225 Bar Injection Pressure

Figure 4 exemplifies the irregularities of HC emission with load for pure diesel and MEMS biodiesels at pressure of 250 bars. The HC emissions are minimal for B30 biodiesel at higher engine loads whereas has HC emissions are higher for B20 biodiesel when the engine operated at higher loads. This shows that HC emissions enhances as the MEMS concentration decreases in the pure diesel.

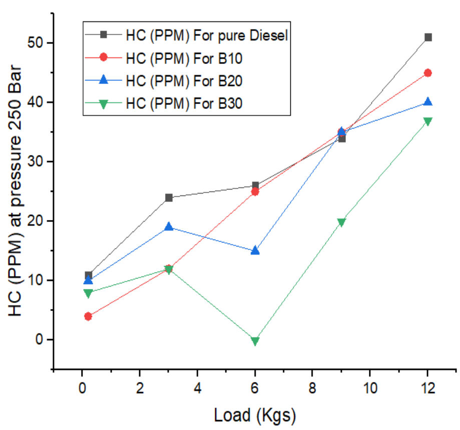

Figure 4: Influence of Engine Load and MEMS Biodiesel on HC Emissions At 250 Bar Injection Pressure

Influence of Engine Load and MEMS Biodiesels on CO Emissions for Coated Engine

Figure 5 exemplifies the irregularities of CO emission with load for pure diesel and MEMS biodiesels at pressure of 210 bars. The quantity of CO emissions released in the engine was mainly due to amount of deficiency of oxygen supplied and its viscosity of the diesel. The CO emissions released were minimal for medium engine load. The CO emissions were boosts when the engine load enhances. The CO emissions were higher for B10 biodiesel and CO emissions were lower for B30 biodiesel.

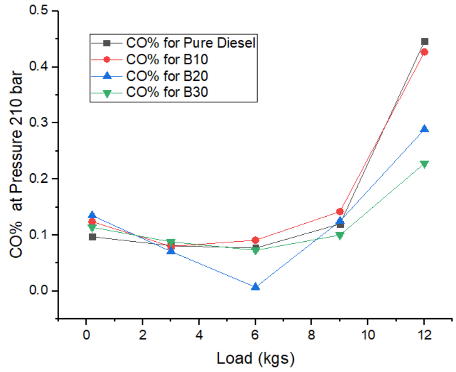

Figure 5: Influence Of Engine Load And MEMS Biodiesel On CO Emissions At 210 Bar Injection Pressure

Figure 6 exemplifies the irregularities of CO emission with load for pure diesel and MEMS biodiesels at pressure of 225 bars. The quantity of CO emissions released in the engine was mainly due to amount of deficiency of oxygen supplied and its viscosity of the diesel. The CO emissions released were minimal for medium engine load. The CO emissions were boosts when the engine load enhances. The CO emissions were higher for B10 biodiesel and CO emissions were lower for B30 biodiesel. The CO emissions decline as the MEMS concentration boosts in the pure diesel.

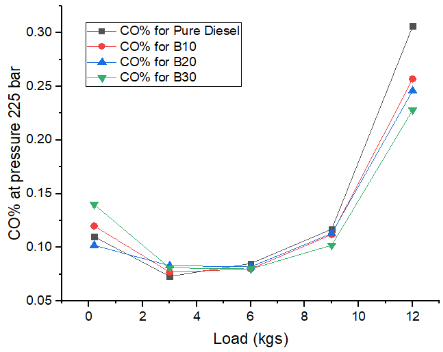

Figure 6: Influence of Engine Load and MEMS Biodiesel on CO Emissions at 225 Bar Injection Pressure

Figure 7 demonstrate the irregularities of CO emission with load for pure diesel and MEMS biodiesels at pressure of 250 bars. The quantity of CO emissions released in the engine was mainly due to amount of deficiency of oxygen supplied and its viscosity of the diesel. The CO emissions released were minimal for medium engine load. The CO emissions were boosts when the engine load enhances. The CO emissions were higher for B10 biodiesel and CO emissions were lower for B30 biodiesel. The CO emissions decline as the MEMS concentration boosts in the pure diesel.

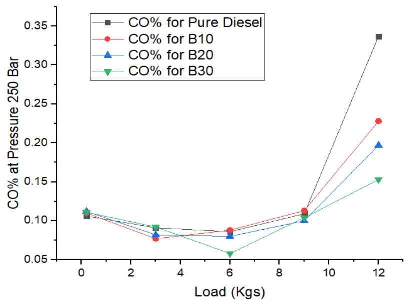

Figure 7: Influence of Engine Load and MEMS Biodiesels on CO_2 Emissions for Coated Engine

Influence of Engine Load and MEMS Biodiesels on CO_2 Emissions for Coated Engine

Figure 8 exemplifies the irregularities of CO_2 emission with load for pure diesel and MEMS biodiesels at injection pressure of 210 bars. The CO_2 emissions enhances as the engine load increases for pure diesel and MEMS biodiesels. The CO_2 emissions were higher for B10 biodiesel and CO_2 emissions were lower for B30 biodiesel. This shows that CO_2 emissions decline as the MEMS concentration boosts in the pure diesel.

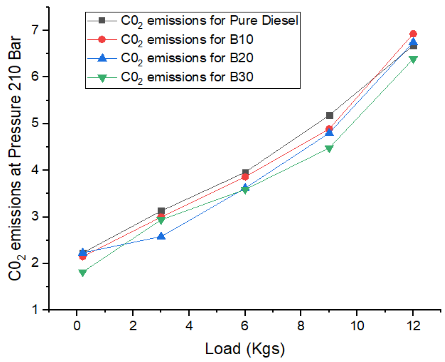

Figure 8: Influence of Engine Load and MEMS Biodiesel on CO_2 Emissions at 210 Bar Injection Pressure

Figure 9 indicates the irregularities of CO_2 emission with load for pure diesel and MEMS biodiesels at injection pressure of 225 bars. The CO_2 emissions enhances as the engine load increases for pure diesel and MEMS biodiesels. The CO_2 emissions were higher for B10 biodiesel and CO_2 emissions were lower for B30 biodiesel. This shows that CO_2 emissions decline as the MEMS concentration boosts in the pure diesel

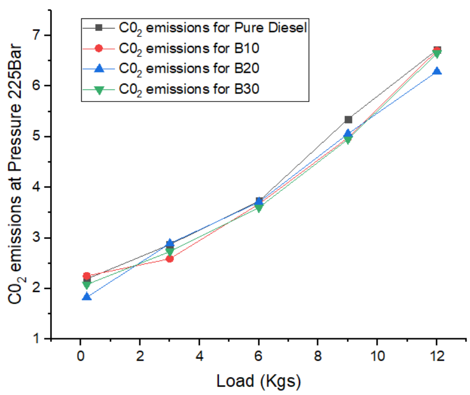

Figure 9: Influence of Engine Load and MEMS Biodiesel on CO_2 Emissions at 225 Bar Injection Pressure

Figure 10 indicates the irregularities of CO_2 emission with load for pure diesel and MEMS biodiesels at injection pressure of 250 bars. The CO_2 emissions enhances as the engine load increases for pure diesel and MEMS biodiesels. The CO_2 emissions were higher for B10 biodiesel and CO_2 emissions were lower for B30 biodiesel. This shows that CO_2 emissions decline as the MEMS concentration boosts in the pure diesel.

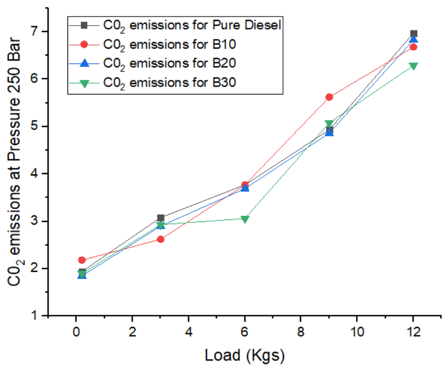

Figure 10: Influence of Engine Load and MEMS Biodiesel on CO2 Emissions at 250 Bar Injection Pressure

Influence of Engine Load and Biodiesel Blend Concentration on O_2 Emissions for Coated Engine

Figure 11 exemplifies the irregularities of O_2 emission with load for pure diesel and MEMS biodiesels at injection pressure of 210 bars. The O_2 emissions decreases as the engine load augments for pure diesel and MEMS biodiesels. The O_2 emissions were higher for low engine load. The emissions of O_2 at 210 bars were found to be higher for B30 biodiesel in case of coated engine condition.

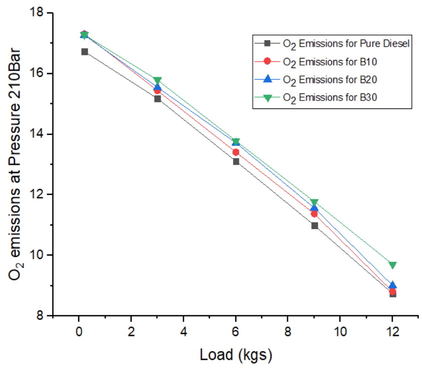

Figure 11: Influence of Engine Load and MEMS Biodiesel on O2 Emissions at 210 Bar Injection Pressure

Figure 12 exemplifies the irregularities of O_2 emission with load for pure diesel and MEMS biodiesels at injection pressure of 225 bars. The O_2 emissions decreases as the engine load augments for pure diesel and MEMS biodiesels. The O_2 emissions were higher for low engine load. The emissions of O_2 at 210 bars were found to be higher for Pure diesel in case of coated engine condition.

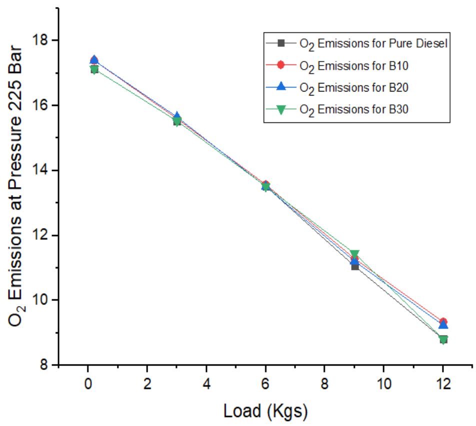

Figure 12: Influence of Engine Load and MEMS Biodiesel on O2 Emissions at 225 Bar Injection Pressure

Figure 13 demonstrates the irregularities of O_2 emission with load for pure diesel and MEMS biodiesels at injection pressure of 250 bars. The O_2 emission decreases has the engine load augments for pure diesel and MEMS biodiesels. The O_2 emissions were higher for low engine load. The emissions of O_2 at 210 bars were found to be higher for B20 biodiesel in case of coated engine condition for lower engine load

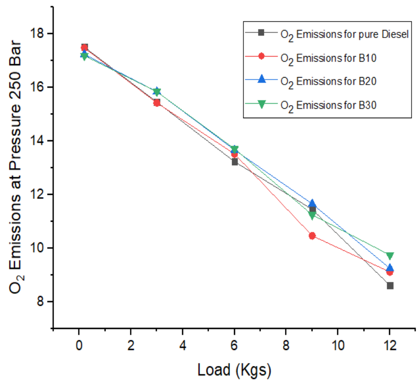

Figure 13: Influence of Engine Load and MEMS Biodiesel on O2 Emissions at 250 Bar Injection Pressure

Influence of Engine Load and MEMS Biodiesel on No_x Emissions for Coated Engine

Figure 14 exemplifies the irregularities of NO_x emission with load for pure diesel and MEMS biodiesels at injection pressure of 210 bars. The NO_x emission increases has the engine load augments for pure diesel and MEMS biodiesels. The NO_x emissions were higher at higher engine load. The emissions of NO_x at 210 bars were found to be higher for B30 biodiesel in case of coated engine condition. The graph shows the B20 has best NO_x emission characteristics at 210 bar injection pressure.

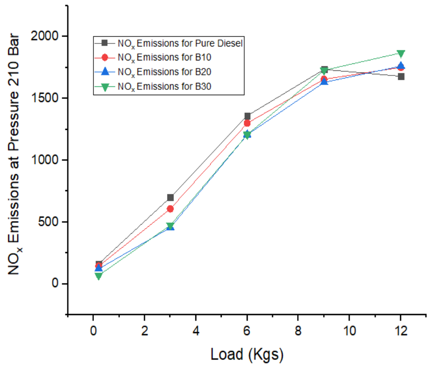

Figure 14: Influence of Engine Load and MEMS Biodiesel on Nox Emissions at 210 Bar Injection Pressure

Figure 15 demonstrate the irregularities of NO_x emission with load for pure diesel and MEMS biodiesels at injection pressure of 225 bars. The NO_x emission increases has the engine load augments for pure diesel and MEMS biodiesels. The NO_x emissions were higher at higher engine load. The emissions of NO_x at 225 bars were found to be higher for B30 biodiesel in case of coated engine condition. The graph shows the B20 has best NO_x emission characteristics at 225 bar injection pressure

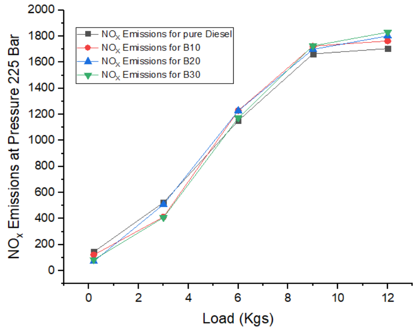

Figure 15: Influence of Engine Load and MEMS Biodiesel on Nox Emissions at 225 Bar Injection Pressure

Figure 16 exemplifies the irregularities of NO_x emission with load for pure diesel and MEMS biodiesels at injection pressure of 250 bars. The NO_x emission increases has the engine load augments for pure diesel and MEMS biodiesels. The NO_x emissions were higher at higher engine load. The emissions of NO_x at 250 bars were found to be higher for B10 biodiesel in case of coated engine condition.

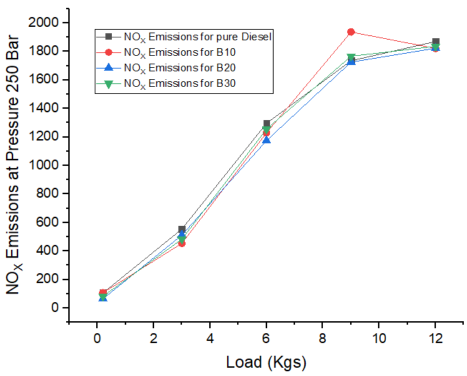

Figure 16: Influence of Engine Load and MEMS Biodiesel on Nox Emissions at 250 Bar Injection Pressure

RESULTS AND DISCUSSIONS OF EMISSIONS FOR NON-COATED ENGINE

Effect of Engine Load and Biodiesel Blend Concentration on HC Emissions for Non-Coated Engine

Figure 17 demonstrates the irregularities of HC emission with load for pure diesel and MEMS biodiesels at pressure of 210 bars. The HC emissions are minimal for B30 biodiesel at higher engine loads whereas has HC emissions are higher for B10 biodiesel when the engine operated at higher loads. The HC emissions released for MEMS biodiesel were nearer to the HC emissions released for pure diesel.

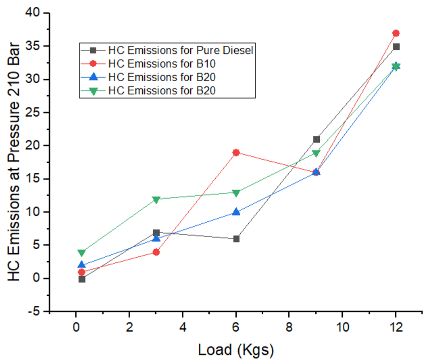

Figure 17: Influence of Engine Load and MEMS Biodiesel on HC Emissions at 210 Bar Injection Pressure

Figure 18 exhibit the irregularities of HC emission on engine load for pure diesel and MEMS biodiesels at pressure of 225 bars. The HC emissions are minimal for B10 biodiesel at higher engine loads whereas has HC emissions are higher for Pure diesel when the engine operated at higher loads. The HC emissions released for MEMS biodiesel were nearer to the HC emissions released for pure diesel.

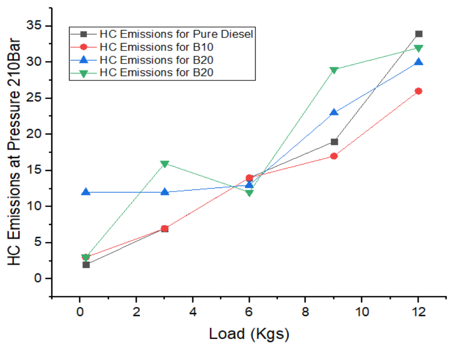

Figure 18: Influence of Engine Load and MEMS Biodiesel on HC Emissions at 225 Bar Injection Pressure

Figure 19 demonstrates the irregularities of HC emission with load for pure diesel and MEMS biodiesels at pressure of 250 bars. The HC emissions are minimal for B10 biodiesel at higher engine loads whereas has HC emissions are higher for Pure diesel when the engine operated at higher loads. The HC emissions released for MEMS biodiesel were nearer to the HC emissions released for pure diesel.

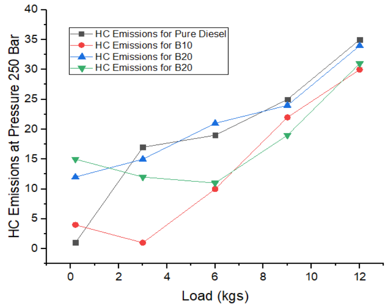

Figure 19: Influence of Engine Load and MEMS Biodiesel on HC Emissions at 250 Bar Injection Pressure

Influence of Engine Load and MEMS Biodiesel on CO Emissions for Non-Coated Engine

Figure 20 exemplifies the irregularities of CO emission on engine load for pure diesel and MEMS biodiesels at pressure of 210 bars. The quantity of CO emissions released in the engine was mainly due to amount of deficiency in oxygen supplied and viscosity of the diesel. The CO emissions released were minimal for medium engine load. The CO emissions were boosts when the engine load enhances. The CO emissions were higher for B10 biodiesel and CO emissions were lower for Pure diesel.

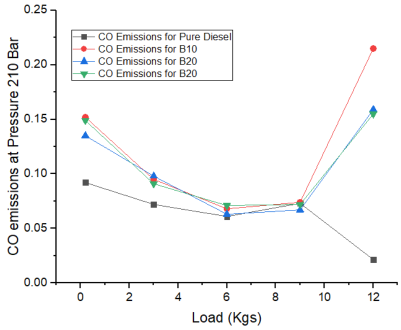

Figure 20: Influence of Engine Load and MEMS Biodiesel on CO Emissions at 210 Bar Injection Pressure

Figure 21 represents the irregularities of CO emission on engine load for pure diesel and MEMS biodiesels at pressure of 225 bars. The quantity of CO emissions released in the engine was mainly due to amount of deficiency in oxygen supplied and viscosity of the diesel. The CO emissions released were minimal for medium engine load. The CO emissions were higher at lower engine load. The CO emissions were higher for B20 biodiesel and CO emissions were lower for Pure diesel.

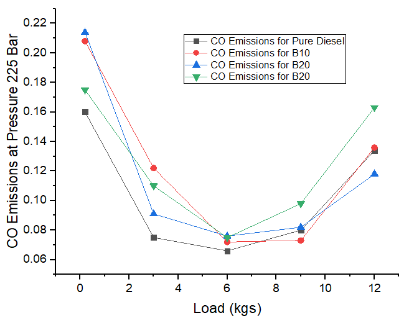

Figure 21: Influence of Engine Load and MEMS Biodiesel on CO Emissions at 225 Bar Injection Pressure

Figure 22 represents the irregularities of CO emission on engine load for pure diesel and MEMS biodiesels at pressure of 250 bars. The CO emissions released were minimal for medium engine load. The CO emissions were higher at lower engine load. The CO emissions were higher for B30 biodiesel and CO emissions were lower for B10 biodiesel

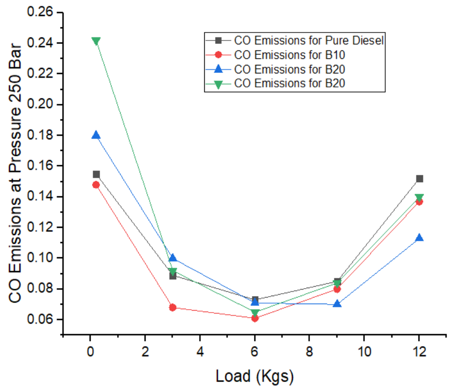

Figure 22: Influence of Engine Load and MEMS Biodiesel on CO Emissions at 250 Bar Injection Pressure

Influence of Engine Load and MEMS Biodiesel on CO_2 Emissions for Non-Coated Engine

Figure 23 indicates the irregularities of CO_2 emission on engine load for pure diesel and MEMS biodiesels at injection pressure of 210 bars. The CO_2 emission enhances has the engine load increases for pure diesel and MEMS biodiesels. The CO_2 emissions were higher for Pure diesel and CO_2 emissions were lower for B30 biodiesel. This shows that CO_2 emissions decline has the MEMS concentration boosts in the pure diesel.

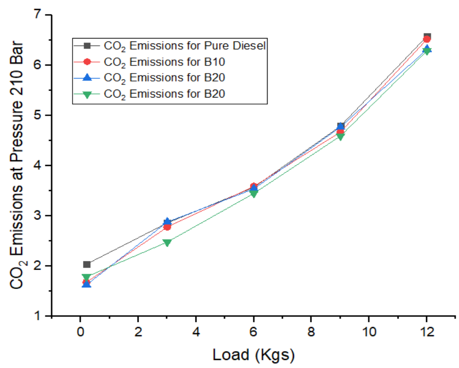

Figure 23: Influence of Engine Load and MEMS Biodiesel on CO_2 Emissions at 210 Bar Injection Pressure

Figure 24 indicates the irregularities of CO_2 emission on engine load for pure diesel and MEMS biodiesels at injection pressure of 225 bars. The CO_2 emission enhances has the engine load increases for pure diesel and MEMS biodiesels. The CO_2 emissions were higher for B30 biodiesel and CO_2 emissions were lower for B10 biodiesel. This shows that CO_2 emissions decline has the MEMS concentration boosts in the pure diesel

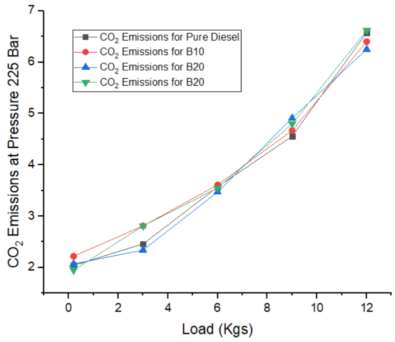

Figure 24: Influence of Engine Load and MEMS Biodiesel on CO_2 Emissions at 225 Bar Injection Pressure

Figure 25 indicates the irregularities of CO_2 emission on engine load for pure diesel and MEMS biodiesels at injection pressure of 250 bars. The CO_2 emission enhances has the engine load increases for pure diesel and MEMS biodiesels. The CO_2 emissions were higher for B20 biodiesel and CO_2 emissions were lower for B30 biodiesel at maximum engine load. This shows that CO_2 emissions decline has the MEMS concentration boosts in the pure diesel.

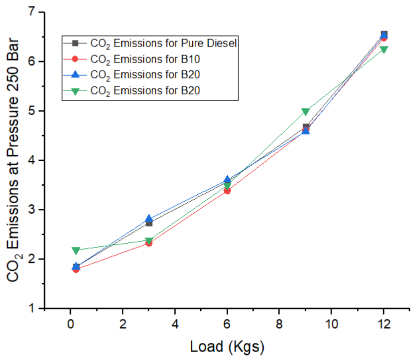

Figure 25: Influence of Engine Load and MEMS Biodiesel on CO_2 Emissions at 250 Bar Injection Pressure

Influence of Engine Load and MEMS Biodiesel on O_2 Emissions for Non-Coated Engine

Figure 26 exemplifies the irregularities of O_2 emission on engine load for pure diesel and MEMS biodiesels at injection pressure of 210 bars. The O_2 emission decreases has the engine load augments for pure diesel and MEMS biodiesels. The O_2 emissions were higher for low engine load. The O_2emissions at 210 bars were found to be higher for B30 biodiesel in case of un-coated engine condition

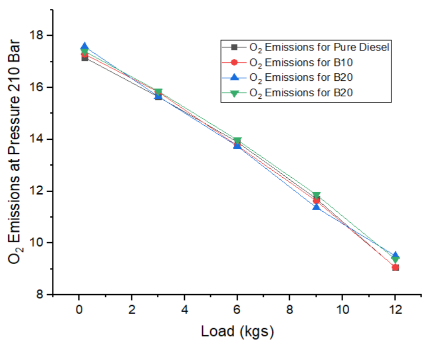

Figure 26: Influence of Engine Load and MEMS Biodiesel on O_2 Emissions at 210 Bar Injection Pressure

Figure 27 exemplifies the irregularities of O_2 emission on engine load for pure diesel and MEMS biodiesels at injection pressure of 225 bars. The O_2 emission decreases has the engine load augments for pure diesel and MEMS biodiesels. The O_2 emissions were higher for low engine load. The O_2 emissions at 225 bars were found to be higher for B30 biodiesel in case of un-coated engine condition

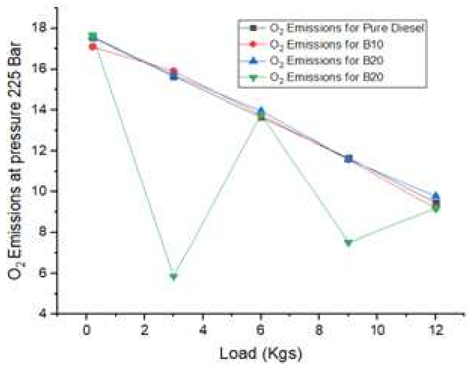

Figure 27: Influence of Engine Load and MEMS Biodiesel on O_2 Emissions at 225 Bar Injection Pressure

Figure 28 represents the irregularities of O_2 emission on engine load for pure diesel and MEMS biodiesels at injection pressure of 250 bars. The O_2 emission decreases has the engine load augments for pure diesel and MEMS biodiesels. The O_2 emissions were higher for low engine load. The O_2emissions at 210 bars were found to be higher for B30 biodiesel in case of un-coated engine condition

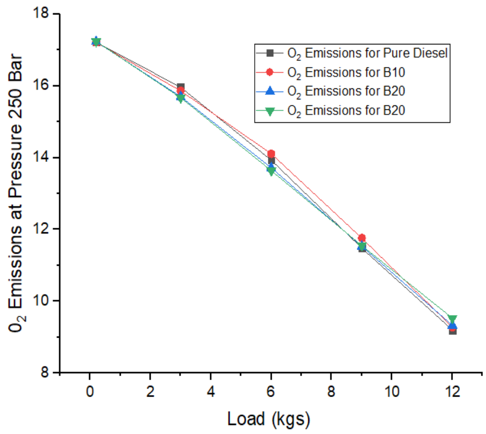

Figure 28: Influence of Engine Load and MEMS Biodiesel on O_2 Emissions at 250 Bar Injection Pressure

Influence of Engine Load and MEMS Biodiesel on No_x Emissions for Non Coated Engine

Figure 29 demonstrate the irregularities of NO_x emission with engine load for pure diesel and MEMS biodiesels at injection pressure of 210 bars. The NO_x emission increases has the engine load augments for pure diesel and MEMS biodiesels. The NO_x emissions were higher at higher engine load. The emissions of NO_x were found to be higher for Pure diesel in case of un-coated engine condition.

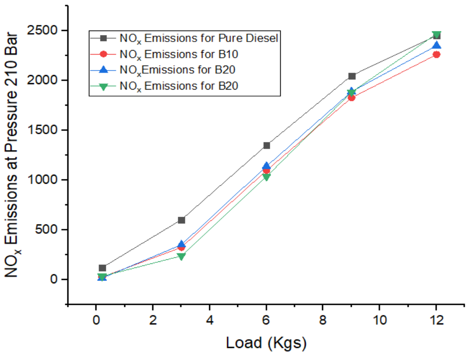

Figure 29: Influence of Engine Load and MEMS Biodiesel on Nox Emissions at 210 Bar Injection Pressure

Figure 30 indicates the irregularities of NO_x emission with engine load for pure diesel and MEMS biodiesels at injection pressure of 225 bars. The NO_x emission increases has the engine load augments for pure diesel and MEMS biodiesels. The NO_x emissions were higher at higher engine load. The emissions of NO_x were found to be higher for B20 biodiesel in case of un-coated engine condition.

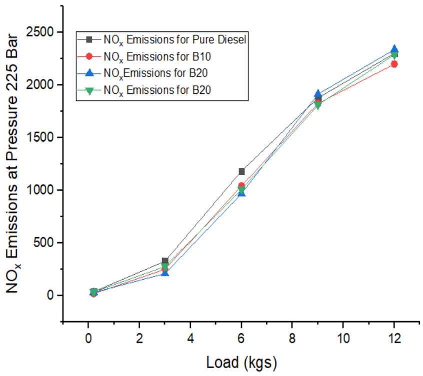

Figure 30: Influence of Engine Load and MEMS Biodiesel on No_x Emissions at 225 Bar Injection Pressure

CONCLUSIONS

The following concussions were drawn from the experimental investigations of MEMS biodiesel fuelled zirconia coated and un-coated 4 stroke diesel engine.

- The MEMS 30% blend biodiesel with zirconia coatings condition shows fewer emissions than that of other blends.
- The emissions released in un-coated condition for B30 biodiesel indicates 6.3% higher than the emissions released in pure diesel fuel at higher engine load.
- The brake thermal efficiency increases by 2.29% in B20 biodiesel with coated condition compared to un-coated condition.
- The use of biodiesel enhances the smoke emission and smoke density in coated engine compared to un-coated engine.
- The NO_x emission level was lower in the coated engine compared to un-coated engine.

- The MEMS biodiesel fuelled TBC coated engine releases 1826 ppm of NO_X emissions compared to un-coated engine at maximum power output than pure diesel fuelled engine.

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